

Sumario

- ❑ Forwarding versus routing
- ❑ Algunos ejercicios de ruteo
- ❑ Dudas / consultas sobre ruteo y capa 3

- ❑ Bibliografía:
 - Principal: Computer Networks. Peterson & Davie. 5º edición
 - Complementaria: Computer Networks. Tanenbaum & Wetherall. 5º edición
 - RFC 2453: RIP Version 2 (hasta sección 3.10.2)

Forwarding versus routing

Forwarding:

- Consiste en **seleccionar** un puerto de **salida** basándose en la dirección destino y en la tabla de ruteo

Routing:

- Proceso por el cual se **construye** la tabla de ruteo

Una tabla de ruteo IP

```
Telnet route-server.videotron.net
route-server.vt1.net>show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 216.113.10.49 to network 0.0.0.0

B    209.205.12.0/24 [200/0] via 216.113.121.52, 2d02h
    68.0.0.0/21 is subnetted, 1 subnets
B    68.233.80.0 [200/0] via 216.113.121.46, 7w0d
    170.226.0.0/24 is subnetted, 1 subnets
B    170.226.8.0 [200/0] via 216.113.121.47, 7w0d
B    205.151.16.0/24 [200/10] via 216.113.121.46, 6w4d
B    208.118.208.0/24 [200/0] via 216.113.121.47, 4w4d
B    207.253.154.0/24 [200/1] via 216.113.121.47, 3w5d
    204.19.17.0/24 is variably subnetted, 3 subnets, 2 masks
B    204.19.17.128/25 [200/0] via 216.113.121.46, 3w4d
B    204.19.17.0/25 [200/0] via 216.113.121.47, 4w4d
B    204.19.17.0/24 [200/0] via 216.113.121.46, 3w4d
B    209.169.183.0/24 [200/0] via 216.113.121.47, 3d08h
B    216.113.99.0/24 [200/10] via 216.113.121.46, 6w4d
```

Ejemplo: el comando show ip route

```
RTA#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, I - ISP
       L - IS-IS, LL - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * indicates candidate default route, * -> user static route, * -> user
       route
Gateway of last resort is not set

R    192.168.4.0/24 [120/1] via 192.168.2.2, 00:00:07, Serial0
      192.168.4.0/24 [120/1] via 192.168.6.1, 00:00:07, Serial1
R    192.168.5.0/24 [120/1] via 192.168.6.1, 00:00:07, Serial1
C    192.168.6.0/24 is directly connected, Serial1
C    192.168.1.0/24 is directly connected, Ethernet0
C    192.168.2.0/24 is directly connected, Serial0
      192.168.2.0/24 is subnetted, 1 subnets
C    192.168.2.128/25 [0/0] via Ethernet1, 00:00:07, Ethernet1
R    192.168.3.0/24 [120/1] via 192.168.2.2, 00:00:07, Serial0
RTA#
```

Code indicating kind of route (points to 'R' in the first line of the route list)

Administrative Distance (points to '[120/1]' in the first line of the route list)

Time since last update (points to '00:00:07' in the first line of the route list)

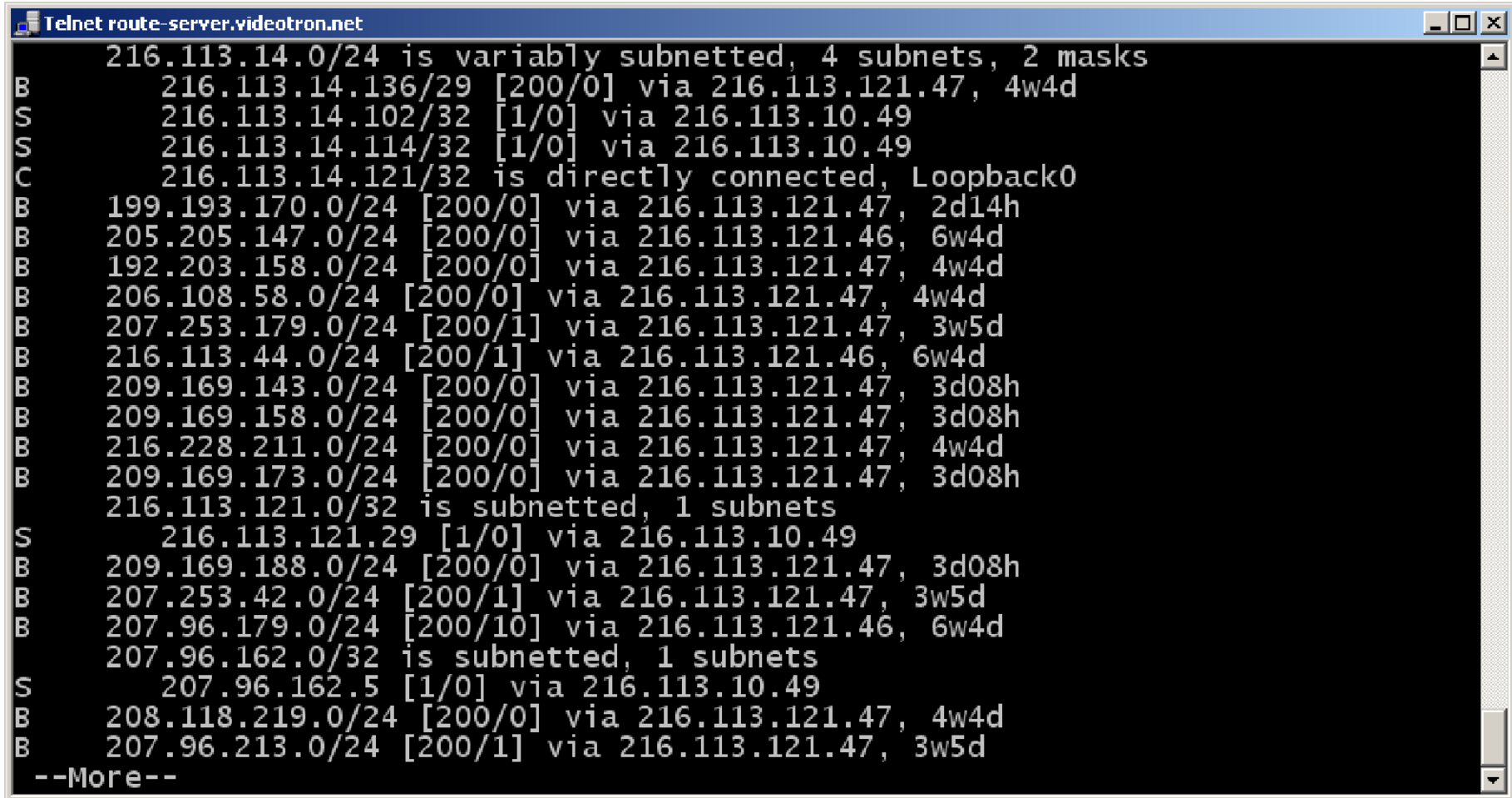
Network and subnet mask for destination (points to '192.168.5.0/24' in the third line of the route list)

Metric (points to '1' in the third line of the route list)

IP address of the next hop (points to '192.168.6.1' in the third line of the route list)

Outbound Interface (points to 'Serial1' in the third line of the route list)

Una tabla de ruteo IP



The screenshot shows a Telnet window titled "Telnet route-server.videotron.net". The window displays a list of IP routes in a structured format. Each entry consists of a letter (B, S, or C) followed by the destination network, mask, and administrative distance in brackets, then the next hop IP and uptime. The routes are as follows:

Type	Destination	Mask	AD	Next Hop	Uptime
216.113.14.0/24 is variably subnetted, 4 subnets, 2 masks					
B	216.113.14.136/29	[200/0]		via 216.113.121.47	4w4d
S	216.113.14.102/32	[1/0]		via 216.113.10.49	
S	216.113.14.114/32	[1/0]		via 216.113.10.49	
C	216.113.14.121/32			is directly connected	Loopback0
B	199.193.170.0/24	[200/0]		via 216.113.121.47	2d14h
B	205.205.147.0/24	[200/0]		via 216.113.121.46	6w4d
B	192.203.158.0/24	[200/0]		via 216.113.121.47	4w4d
B	206.108.58.0/24	[200/0]		via 216.113.121.47	4w4d
B	207.253.179.0/24	[200/1]		via 216.113.121.47	3w5d
B	216.113.44.0/24	[200/1]		via 216.113.121.46	6w4d
B	209.169.143.0/24	[200/0]		via 216.113.121.47	3d08h
B	209.169.158.0/24	[200/0]		via 216.113.121.47	3d08h
B	216.228.211.0/24	[200/0]		via 216.113.121.47	4w4d
B	209.169.173.0/24	[200/0]		via 216.113.121.47	3d08h
216.113.121.0/32 is subnetted, 1 subnets					
S	216.113.121.29	[1/0]		via 216.113.10.49	
B	209.169.188.0/24	[200/0]		via 216.113.121.47	3d08h
B	207.253.42.0/24	[200/1]		via 216.113.121.47	3w5d
B	207.96.179.0/24	[200/10]		via 216.113.121.46	6w4d
207.96.162.0/32 is subnetted, 1 subnets					
S	207.96.162.5	[1/0]		via 216.113.10.49	
B	208.118.219.0/24	[200/0]		via 216.113.121.47	4w4d
B	207.96.213.0/24	[200/1]		via 216.113.121.47	3w5d

--More--

Una tabla de ruteo IP

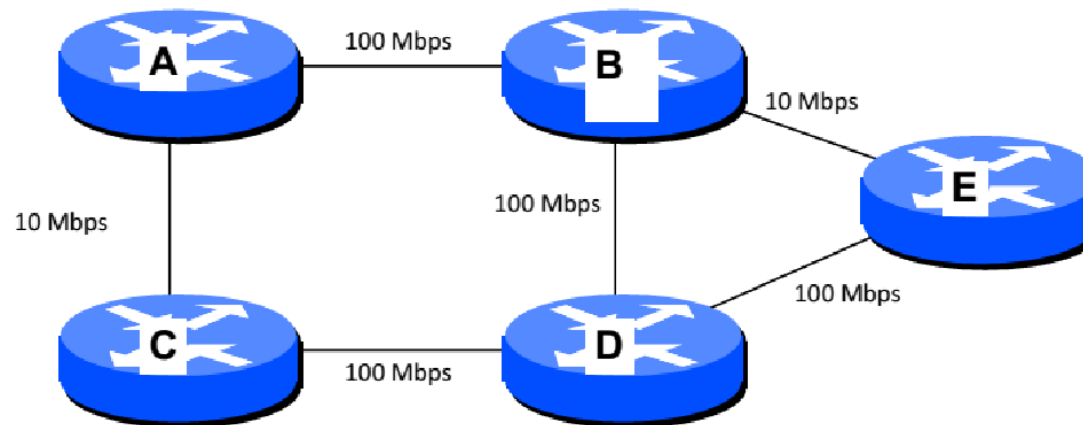
```
Telnet route-server.videotron.net
B 209.169.169.0/24 [200/0] via 216.113.121.47, 5d10h
B 209.169.184.0/24 [200/0] via 216.113.121.47, 5d10h
216.113.10.0/30 is subnetted, 1 subnets
C 216.113.10.48 is directly connected, GigabitEthernet0/0
B 199.193.174.0/24 [200/0] via 216.113.121.47, 1d22h
B 208.118.223.0/24 [200/0] via 216.113.121.47, 1d22h
207.96.209.0/24 is variably subnetted, 4 subnets, 3 masks
B 207.96.209.52/30 [200/0] via 216.113.121.47, 7w0d
B 207.96.209.48/30 [200/0] via 216.113.121.46, 6w6d
B 207.96.209.32/28 [200/0] via 216.113.121.46, 4w1d
B 207.96.209.192/26 [200/0] via 216.113.121.47, 7w0d
B 205.151.44.0/24 [200/0] via 216.113.121.47, 7w0d
199.102.200.0/24 is variably subnetted, 3 subnets, 2 masks
B 199.102.200.0/25 [200/0] via 216.113.121.47, 1d22h
B 199.102.200.0/24 [200/0] via 216.113.121.47, 1d22h
B 199.102.200.128/25 [200/0] via 216.113.121.47, 1d22h
B 207.253.106.0/24 [200/0] via 216.113.121.47, 2w6d
B 207.96.243.0/24 [200/90] via 216.113.121.46, 6w6d
B 207.253.12.0/24 [200/90] via 216.113.121.46, 6w6d
B 207.253.63.0/24 [200/90] via 216.113.121.46, 6w6d
S* 0.0.0.0/0 [1/0] via 216.113.10.49
B 192.247.12.0/22 [200/0] via 216.113.121.47, 4w6d
B 207.253.184.0/23 [200/90] via 216.113.121.46, 6w6d
B 199.84.130.0/23 [200/0] via 216.113.121.47, 4w6d
B 207.253.236.0/23 [200/90] via 216.113.121.46, 6w6d
```

Notación para los ejercicios

Network	Next hop
172.16.5.0/24	IF 0/1
10.4.2.0/27	IF 0/0
192.168.2.0/26	10.4.2.25
Default	10.4.2.25

Network (Red)	Next hop (Próximo salto)
Red destino	<ul style="list-style-type: none">• interface de salida, si la red destino se encuentra directamente conectada a esa interface; o bien• dirección IP del próximo salto, si la red destino es una red remota

Ejercicio



Dada la topología de red de la figura:

1. Mostrar la ruta que seguirá un paquete IP una vez que los routers alcanzaron el estado estable:
 - a. Desde A hasta E si construyeron sus tablas utilizando RIP con triggered updates
 - b. Desde E hasta A si construyeron sus tablas utilizando OSPF en área única
2. Se cae el enlace B-D. Explicar los eventos que se desencadenan a partir de este suceso en ambos protocolos.

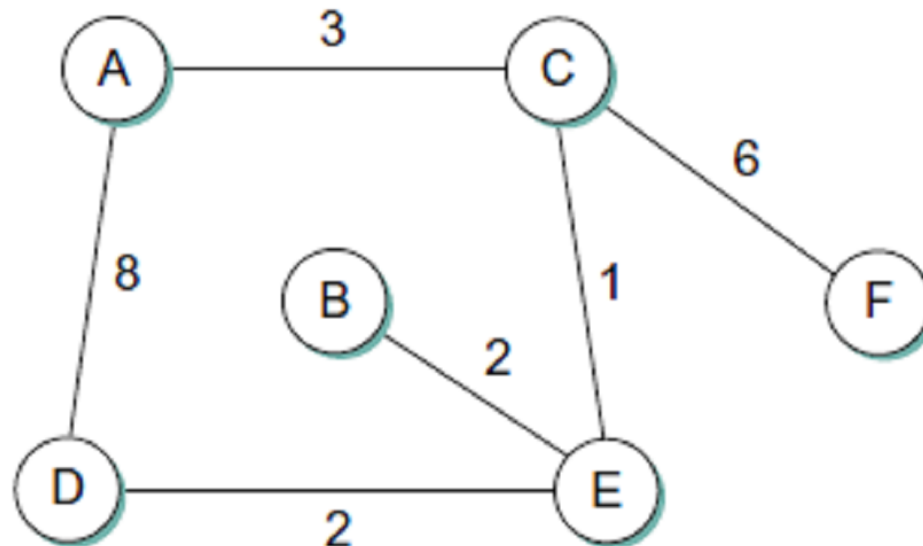
Datos: Métrica de OSPF= $10^8 / \text{Ancho de banda [bps]}$

Solución

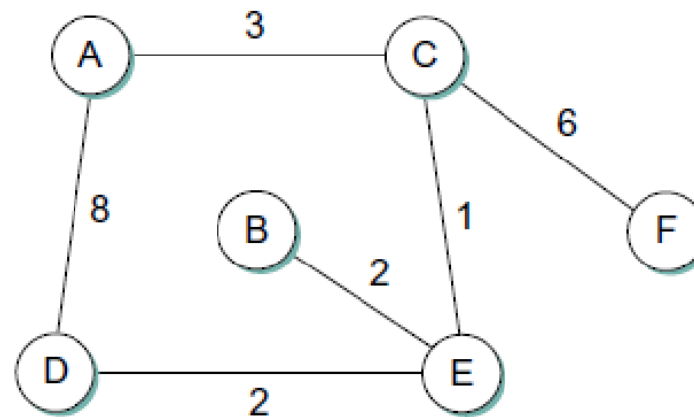
- ❑ RIP: Todos los enlaces métrica 1
- ❑ OSPF: Enlaces de 10 Mbps -> métrica 10; de 100 Mbps -> métrica 1
- ❑ 1.a. (RIP):
 - **A-B-E = 1+1 = 2**
- ❑ 1.b. (OSPF):
 - E-B-A = 10+10 = 20
 - E-B-D-C-A = 10+1+1+10 = 22
 - E-D-C-A = 1+1+10 = 12
 - **E-D-B-A = 1+1+1 = 3**
- ❑ 2. Tanto B como D detectan la caída del enlace. En RIP comienza un intercambio inmediato de tablas de los routers involucrados con sus vecinos (por triggered updates). En OSPF se desencadena un floding de estado del enlace en ambos routers.

Ejercicio

- ▣ Para la red mostrada en la figura, mostrar las tablas globales de distance-vector cuando:
 1. Cada nodo conoce solamente las distancias a sus vecinos inmediatos.
 2. Cada nodo ha reportado la información del paso precedente a sus vecinos inmediatos.
 3. Una segunda repetición del paso anterior.

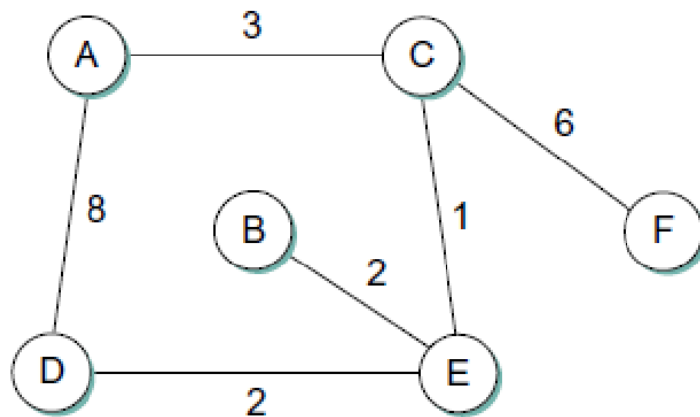


1. Cada nodo conoce solamente las distancias a sus vecinos inmediatos.



Information Stored at Node	Distance to Reach Node					
	A	B	C	D	E	F
A	0	∞	3	8	∞	∞
B	∞	0	∞	∞	2	∞
C	3	∞	0	∞	1	6
D	8	∞	∞	0	2	∞
E	∞	2	1	2	0	∞
F	∞	∞	6	∞	∞	0

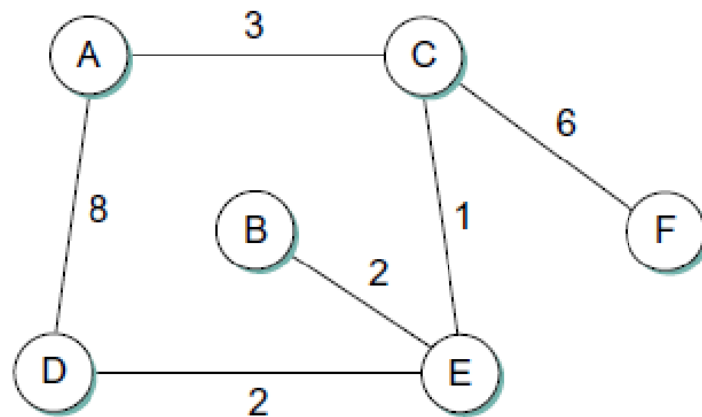
2. Cada nodo ha reportado la información del paso precedente a sus vecinos inmediatos.



Information Stored at Node	Distance to Reach Node					
	A	B	C	D	E	F
A	0	∞	3	8	∞	∞
B	∞	0	∞	∞	2	∞
C	3	∞	0	∞	1	6
D	8	∞	∞	0	2	∞
E	∞	2	1	2	0	∞
F	∞	∞	6	∞	∞	0

Information Stored at Node	Distance to Reach Node					
	A	B	C	D	E	F
A	0	∞	3	8	4	9
B	∞	0	3	4	2	∞
C	3	3	0	3	1	6
D	8	4	3	0	2	∞
E	4	2	1	2	0	7
F	9	∞	6	∞	7	0

3. Una segunda repetición del paso anterior



Information Stored at Node	Distance to Reach Node					
	A	B	C	D	E	F
A	0	∞	3	8	4	9
B	∞	0	3	4	2	∞
C	3	3	0	3	1	6
D	8	4	3	0	2	∞
E	4	2	1	2	0	7
F	9	∞	6	∞	7	0

Information Stored at Node	Distance to Reach Node					
	A	B	C	D	E	F
A	0	6	3	6	4	9
B	6	0	3	4	2	9
C	3	3	0	3	1	6
D	6	4	3	0	2	9
E	4	2	1	2	0	7
F	9	9	6	9	7	0

Conclusiones

- ❑ Routing es un algoritmo distribuido
 - Reacciona ante cambios en la topología
 - Computa los caminos en una red
- ❑ Distance-vector routing
 - Calcula los costos de los caminos basándose en los costos de los caminos de los vecinos
 - Algoritmo Bellman-Ford & Routing Information Protocol
- ❑ Link state routing
 - Inunda los costos de los enlaces en la red
 - Calcula los caminos más cortos como la suma del costo de los enlaces
- ❑ Proceso de convergencia
 - Ante cambios de una topología a otra
 - Períodos transitorios de inconsistencia entre los routers

Algunas herramientas

- ❑ Public Route Servers and Looking Glass sites:
 - <http://www.netdigix.com/servers.html>
 - ❑ Videotron route server (AS5769)
- ❑ ARIN <https://www.arin.net>
 - <http://whois.arin.net/ui/advanced.jsp>
- ❑ LACNIC <http://www.lacnic.net>
 - <http://lacnic.net/cgi-bin/lacnic/whois?lg=SP>
- ❑ Traceroute.org
 - <http://www.traceroute.org/>
- ❑ IP Calculator
 - <http://jodies.de/ipcalc>
- ❑ Online IP Subnet Calculator
 - <http://www.subnet-calculator.com/>

Dudas, consultas ?

